The role of the supramarginal gyrus and inferior frontal gyrus in working memory: is speech special?

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Introduction

Before meaning can be extracted from a verbal message, acoustical and phonological information needs to be extracted and held in phonological working memory. This complex set of phonological processes is supported by a distributed network of cortical and subcortical regions that includes the anterior supramarginal gyrus (aSMG) and the posterior inferior frontal gyrus (pIFG) [1, 2]. It has been suggested that these two regions are implicated in distinct phonological working memory mechanisms. While the aSMG would temporarily hold phonological information in working memory, the pIFG, in contrast, would serve to refresh phonological information in the short-term store through subvocal articulatory rehearsal mechanisms [3, 4]. However, the exact contribution of these regions to phonological working memory mechanisms remains unclear as the pIFG is recruited during the discrimination and manipulation of sequences of both speech and non-speech sounds [5] and the aSMG is recruited during both verbal and non-verbal working memory tasks [6]. To investigate the role of the pIFG and aSMG in phonological working memory, a priming paradigm was used to target implicit memory effects during the processing of speech and non-speech sequences.

Method

Participants

- 18 participants (10 females, 17-35 years old)
- No contraindication to MRI or TMS
- Normal cognitive level (MOCA 29±0.9/30)
- Normal hearing (pure tone audiometry)

Experimental task

- Memory tasks (N-back, Sternberg; Fig. 1)
- Auditory discrimination task with two categories of sounds (bird songs and syllables; Fig. 2)
- Performance measured in terms of RTs and accuracy

TMS equipment

- Super Rapid2 stimulator (Magstim, UK) with neuronavigation system (Brainsight: Rogue Research)
- Surface electromyography electrodes to the right FDI muscle

TMS protocol (Fig. 3)

- Passive motor threshold (MT) (FDI muscle; min. of 50mV, 5/10 trials)
- Stimulation intensity for experiment = 110% of MT(59.7±7.6%)
- Online single pulse TMS to two targets: pIFG and aSMG, at 2 stimulation times (250ms [maintenance phase], 500ms [rehearsal phase]) during the discrimination task
- 384 trials in total including 192 on each site and 48 sham

Analyses

- rANOVAs on RTs (i.e. difference between identical and different sequences) and accuracy with target (pIFG, aSMG) and stimulation time as the within-subject factors were conducted for each auditory category (bird songs, syllables)

Method

Figure 1. Memory tests

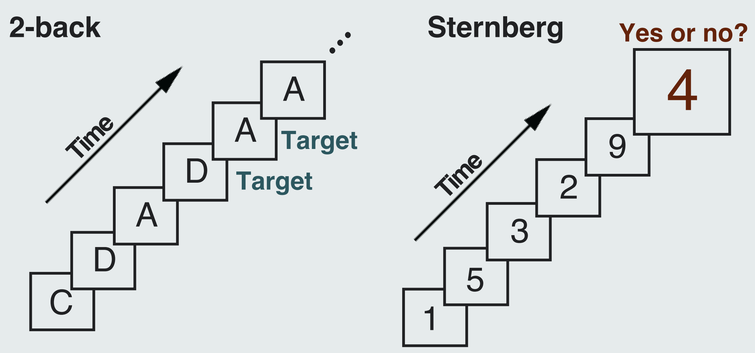


Figure 2. Auditory discrimination task

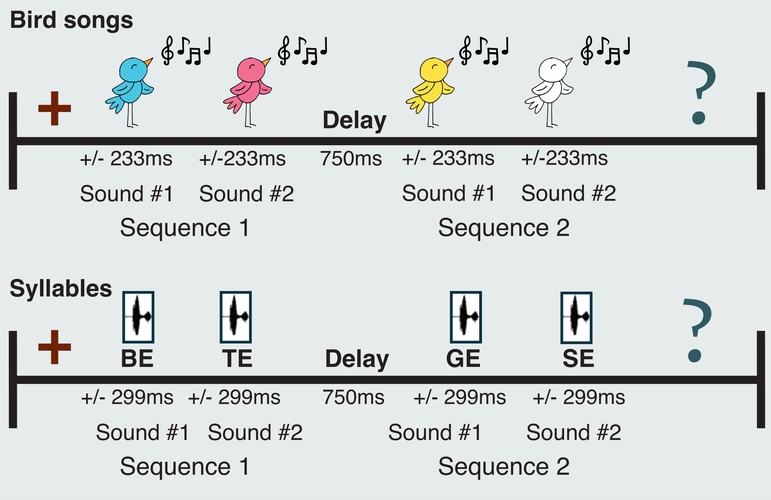
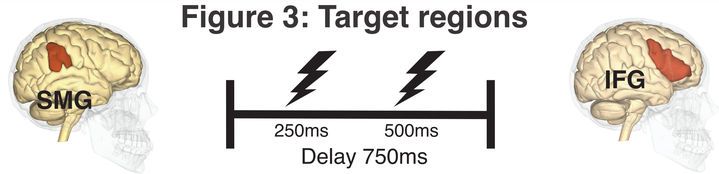


Figure 3: Target regions



Discussion

Preliminary results show that stimulation to the pIFG and aSMG during the maintenance phase disrupts performance (i.e. RTs) only during the processing of syllable sequences, while stimulation of these regions during the rehearsal phase disrupts performance (i.e. accuracy) only during the processing of bird song sequences.

These results suggest that during the maintenance phase, both pIFG and aSMG are involved in the maintenance of phonological information in working memory, whereas during the later phase, these regions would contribute to domain general working memory mechanisms, as bird sequences cannot be rehearsed.

Additional analyses are underway to examine whether the relationship between TMS to the pIFG and the aSMG and auditory discrimination is moderated by working memory capacities.

Results

Figure 4. Audiometry (PTA)

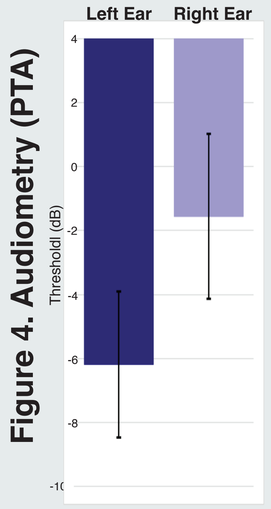


Figure 5. N-Back task

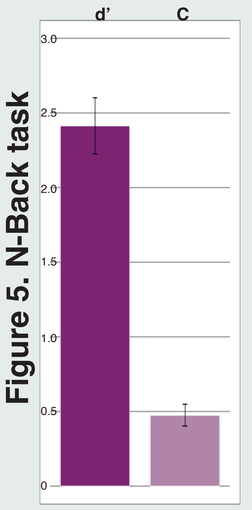


Figure 6. Discrimination accuracy

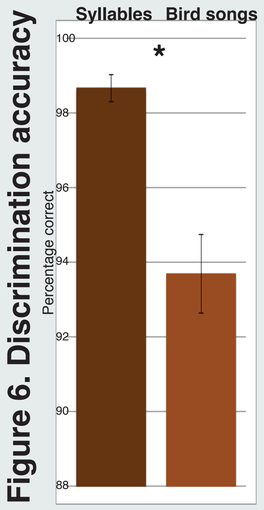
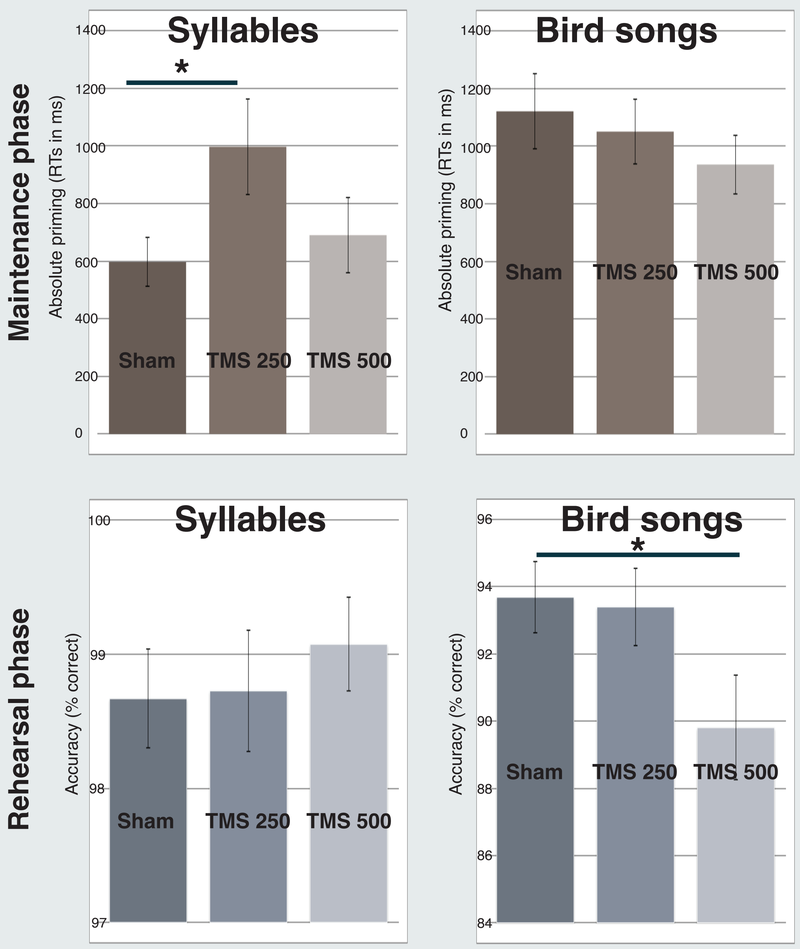


Figure 7. Priming effect



References

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Acknowledgments

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